Quality Assurance

1. INTRODUCTION

Every industry producing goods or services is confronted with the subject of quality. Their products are in the true sense of the word qualified by the customer with respect to the extent they meet his expectations. Included in his expectations is a conception of the price; thus, quality cannot be dealt with apart from cost aspects: on one hand, a product able to fulfill high and special requirements usually fetches a higher price than a "middle of the road" product; on the other hand, its production costs are as a rule also higher. Furthermore and that is not of less importance for the producer the market for a highly specialized product might be limited and the profitability questionable in spite of the high specific selling price.

It is the fundamental task of the quality assurance of a company to deal with the product quality and its relation to production costs, selling price and market potential, with the objective to manufacture a profitable product.

The establishment of an efficient quality assurance and its integration within all levels of company organisation, has for many companies been the basis for their success the brilliant advance of various sectors of the Japanese industry is an impressioning example.

In view of this experience, a generally applicable concept of quality assurance has been systematically developed, and has reached now the stage where quality assurance systems are specified in national or international standards.

Also in the cement industry, the needs for a well conceived quality assurance have significantly increased over the last twenty years, mainly due to the following developments:

- more stringent requirements on concrete and cement
- growing competition due to over-capacities
- escalating energy costs
- more efficient - though also more delicate - production facilities
- increasingly tighter environmental regulations
- involvement in active environmental protection

2. DEFINITION OF QUALITY AND ITS CEMENT RELATED INTERPRETATION

Quality is defined as follows:
Quality is the totality of features and characteristics of a product that bear on its ability to satisfy a given need or fulfill certain requirements [1].

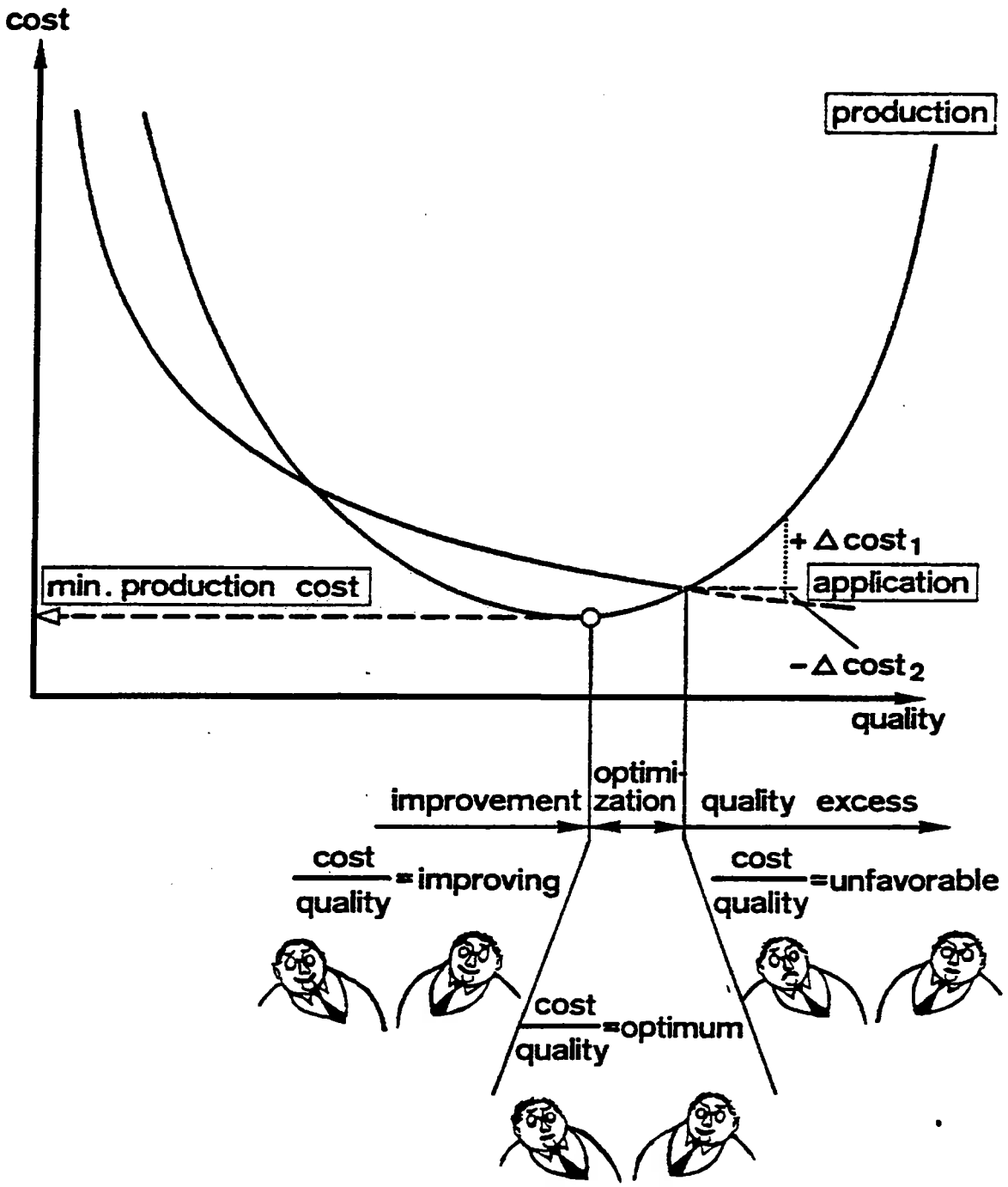
It is obvious that cement producers and consumers have a different attitude towards cement quality.

- The cement manufacturer is above all interested in low investment and production costs. Quality, therefore, is primarily associated with costs for materials, energy, equipment and labour. His major concern usually was - and often still is - concentrated on the suitability and uniformity of raw materials and intermediate products to allow optimum operation of the expensive installations with respect to quantity and costs.
- On the other hand, the consumer expects a product with favourable characteristics for its many applications. The changed market conditions - these days most countries envisage a very pronounced buyer's market - put him in a very strong position with regard to quality requirements. He need not be satisfied by the mere fulfilment of the standard specifications of the purchased cement, but may well demand more stringent requirements. Often, these additive requirements mean higher strengths and excellent uniformity - permitting to minimize this, according to the user, expensive ingredient in concrete - but they can also refer to other properties such as rheology (concrete workability) or colour. Furthermore, the consumer may urge the producer for detailed information not only about the final product, but even on all stages of cement manufacture. This may ultimately result in periodic inspection visits to the plant by external officials to so-called protect the consumers interests. Quality assurance by the cement manufacturer, therefore, is interpreted by the consumer as quality insurance in the sense of product liability.

Hence, the quality requirements of producers and consumers are by far not congruent; while a certain limitation of the product variability is generally in line with the manufacturer's attitude towards quality, his product costs can be seriously affected by the user's request for pushed quality levels, excessive uniformity and special requirements (Fig. 1). Depending on the suitability of the available raw materials, correctives, additives etc., it will be more or less costly for the manufacturer, if he has to comply with all the specific requirements. Moreover, the requirements of the two parties change significantly with time, and this change does usually not follow along the same lines.

[1] ISO 8402 - 1986: Quality : Vocabulary

Fig 1 Cost/Quality Relation



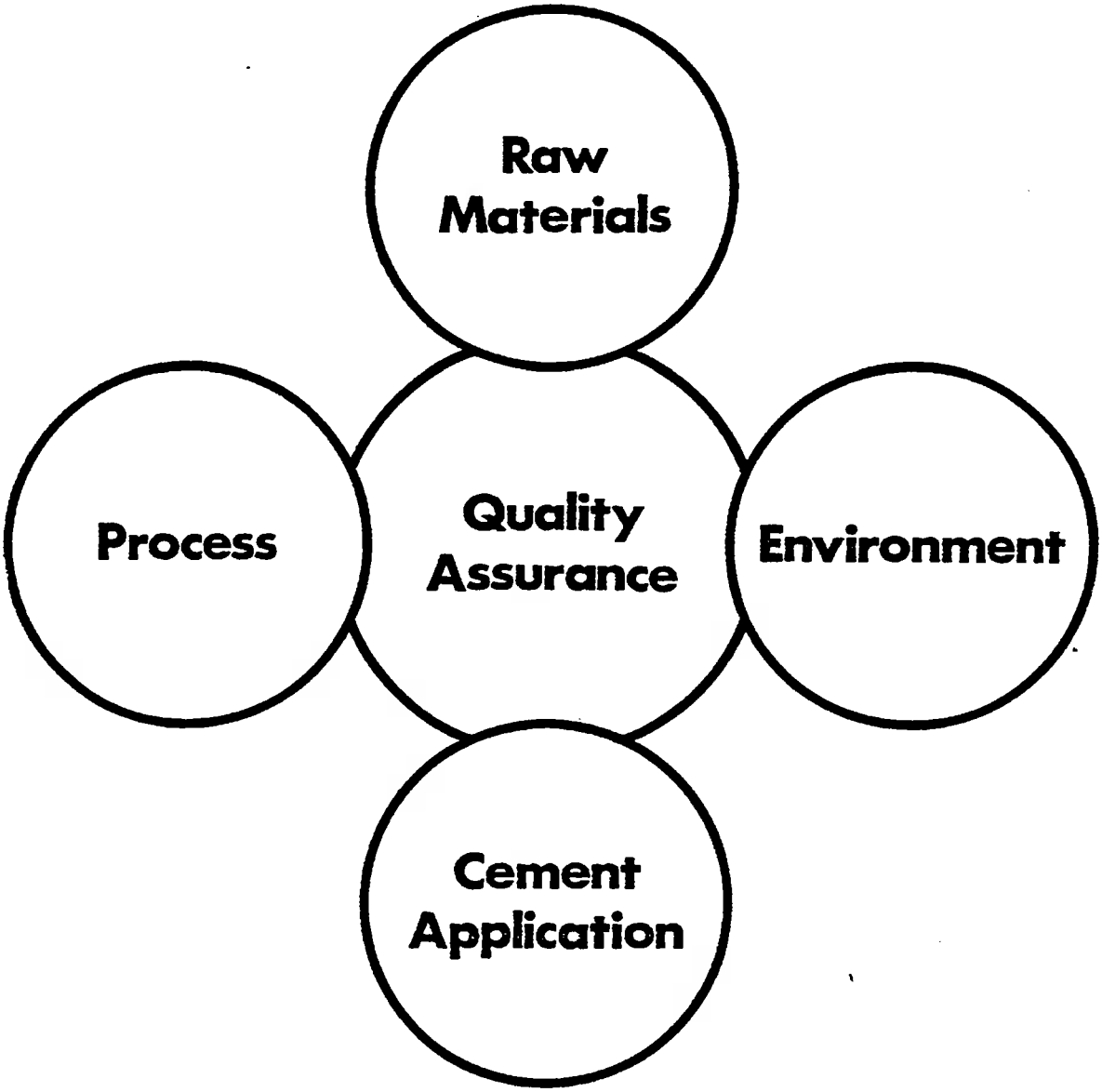
3. OBJECTIVES OF QUALITY ASSURANCE

It is the task of quality assurance to find an appropriate compromise between the divergent interests of producer and consumer.

More specifically, quality assurance has to ensure (Fig. 2):

- the manufacturing of market-conform products
- a smooth process by an appropriate design of the raw mix and other intermediates
- an economic utilisation of raw materials
- the compliance with environmental regulations

Fig 2 Objectives of Quality Assurance



The prevailing trends within these four subjects can be summarised as follows:

1) cement application:
Product oriented aspects gained in importance over the past years. For many plants it is no longer sufficient to produce cement meeting the standard specifications or any nationally accepted quality level, but they are obliged to adapt their products and product ranges to specific customer requirements, be it for the inland or export market.
The implementation of technical consulting services for cement application provides an important marketing support for many plants in competitive markets.

2) process:
Induced by world-wide cement over-capacities and rising energy costs, plants are under considerable pressure to produce more cost-efficiently. A detailed optimisation of the raw mix and other intermediates with respect to process requirements can significantly contribute to this aim. Rationalisation by means of automatisation of process and quality control are also potential measures. However, they require a careful return-on-investment analysis.

3) raw materials:
Optimal utilisation of raw material deposits, both long - and short-term, has become an economic necessity and is nowadays facilitated by powerful computer programs.
Waste materials - both combustibles and non-combustibles - are successfully utilised in cement manufacturing. Special measures and investigations are necessary prior to and during their application.

4) environmental aspects:
Just as any other industry, the cement industry has to comply with increasingly stringent regulations on emission and immission. Different to most other industries, it offers, however, the possibility to actively contribute to a safe disposal of waste materials by means of their utilisation for cement manufacturing.

4. ACTIVITIES IN QUALITY ASSURANCE

By definition (ISO 8402), quality assurance comprises all those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.

Within the concept of quality assurance, three principle functions are distinguished:

Quality Assurance		
Quality Planning	Quality Control	Quality Audit

4.1 Quality Planning

The basic objective of quality planning is to determine the company's strategy and tactics in quality assurance. This begins with defining the relative significance of quality assurance and its main areas of emphasis, taking the particular situation of a company, e.g. with respect to market or to raw materials resources, into account.

The individual subjects that have to be dealt with are compiled Fig. 3, and can be summarised as follows:

Outwards activities have to include the decision making in co-operation with marketing on number and types of products to be manufactured on the basis of criteria such as: demand of domestic and export market, raw materials situation, plant characteristics, etc.; evaluation of the demand for an extended support of the marketing department, e.g. in form of a technical customer service, and, if required, the realisation of such a service; furthermore, to represent the company's or cement industry's interest in the design of cement and concrete standard specifications or in the environmental legislation, by participation in the respective committees or bodies.

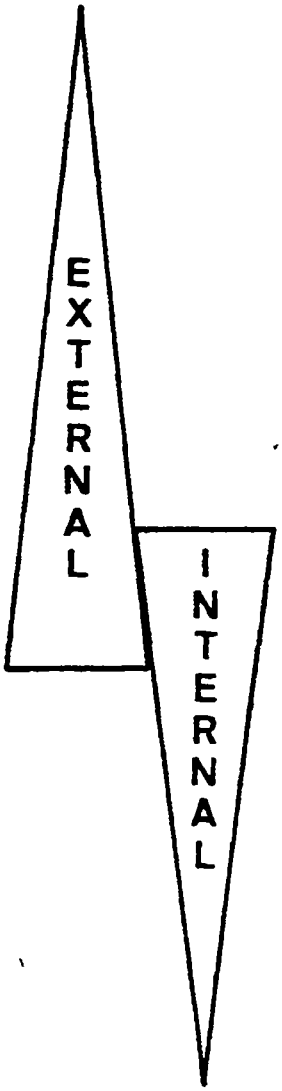
Plant internal planning activities comprise the design of the raw mix(es) as a direct follow-up to product planning and, in the same context, the establishment of a concept for short-and long-term raw material exploitation and securing. Of a very practical relevance is the set-up of a concept for quality control; questions regarding the personnel structure, the equipment, the degree of automation as well as data-processing and communication are of primary importance. Last but not least it is also incumbent on quality planning to increase the knowledge on the quality criteria and to develop a quality consciousness of the personnel by adequate training. Addressants are on the one hand the management of both the production and marketing sectors, and, on the other hand, the subordinate staff and unskilled labour members, since it will ultimately depend on them whether quality assurance is properly observed in all sectors of the plant activities.

Fig 3 Quality Planning

QUALITY PLANNING

STATEGY AND TACTICS

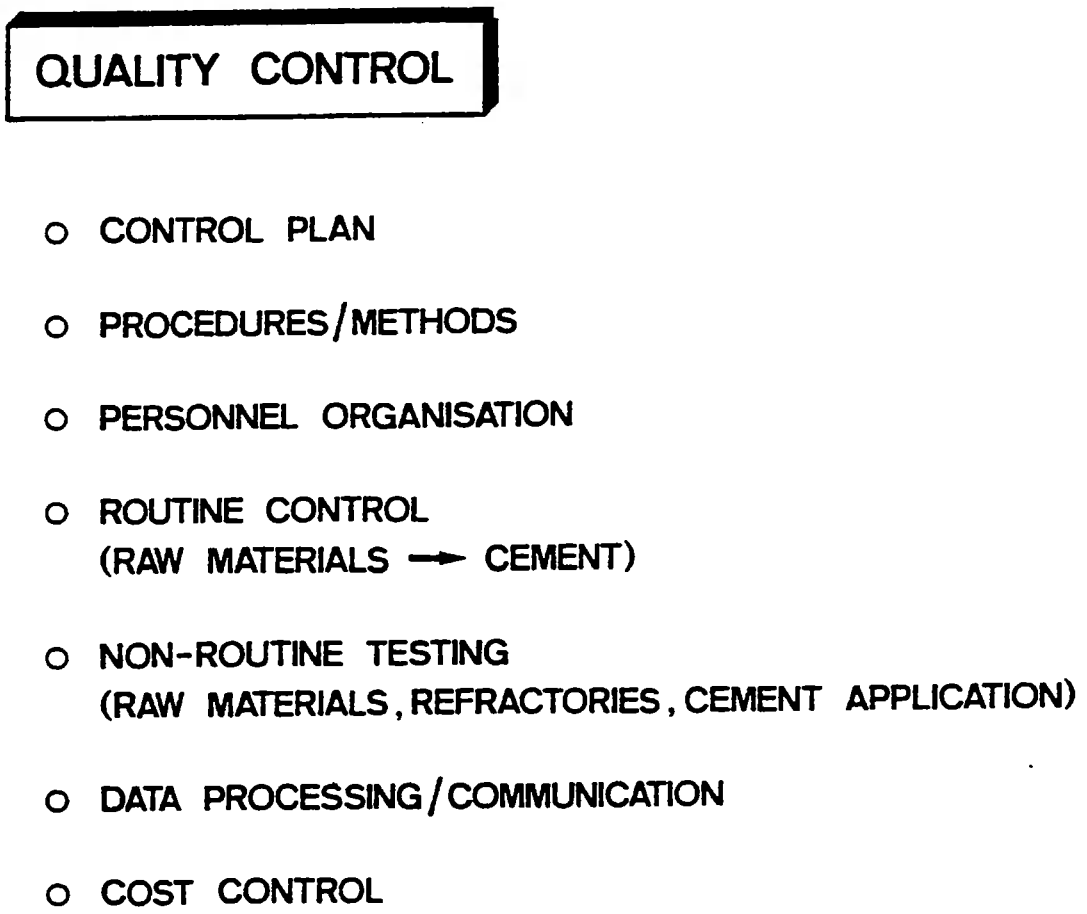
- PROFESSIONAL ORGANISATIONS
- ENVIRONMENTAL LEGISLATION
- STANDARD COMMITTEES
- TECHNICAL CUSTOMER SERVICE
- MARKET
- MATERIAL RESOURCES
- PRODUCT DESIGN
- MIX DESIGN
- EXPLOITATION CONCEPT
- CONTROL CONCEPT
- EDUCATION/TRAINING



4.2 Quality Control

The task of the quality control (Fig. 4) is the routine monitoring of material properties throughout the process and the initiation of necessary adjustments in the process controls. The pre-requisite are an elaborate control plan and well - established methods and procedures for sampling and testing. It needs no particular mention that the infrastructure of quality control can also be used for non-routine purposes.

Fig 4 Quality Control



In view of new technologies, special attention has to be paid nowadays to data storage, processing, presentation as well as to data communication to the plant management and to process and sales departments. Data processing and communication not only serve to initiate process control measures - which can, in certain cases, be done directly by computer control - but also as a "quality certificate" for produced or dispatched products and as basic information for quality planning.

4.3 Quality Audit

Quality audit - as an integral part of the QA system - has the objective to critically scrutinise from time to time the procedures and efficiency of quality planning and quality control and to suggest adjustments if deemed necessary. Particular reasons for performing a quality audit are certainly significant changes, e.g. in the market situation, in the raw material situation or in the plant itself (extension, shut-down of production lines). It might be sensible to have a quality audit carried out by a third party in order to ensure an unbiased approach.

5. QUALITY ASSURANCE SYSTEM

5.1 The Elements of a Quality Assurance System

In slight deviation from the official definitions, quality assurance system may be defined as the organisational structure, responsibilities, procedures, processes and resources for implementing quality assurance.[1]

In very general terms, the elements of a quality assurance system comprise:

- Organisation of personnel, dedication of tasks and responsibilities
- Lines of communication of information and decisions in routine and non-routine situations
- Quality control proper, i.e. sampling, testing, initiation or direct performance of reactions (automatic and manual)
- Training scheme
- Technical customer service
- Co-operation with external official bodies
- Quality cost control

It is evident that a quality assurance system has to be individually tailored to the specific needs of a company, taking regard of the complexity of the plant situation, of the prevailing market situation, and of the relationship with official institutions.

Detailed lists and descriptions of the required elements of a quality assurance system are contained in national or international standards, particularly in the ISO 9000 standard series. Companies meeting the standard requirements can have their quality assurance systems certified by recognised certification organisations. The ISO 9000 standard series or quality assurance systems find increasing application in the cement industry, in respond to corresponding demands from the market or from product conformity certification schemes (see report MA 91/3866/E).

5.2 Organisation of Quality Assurance

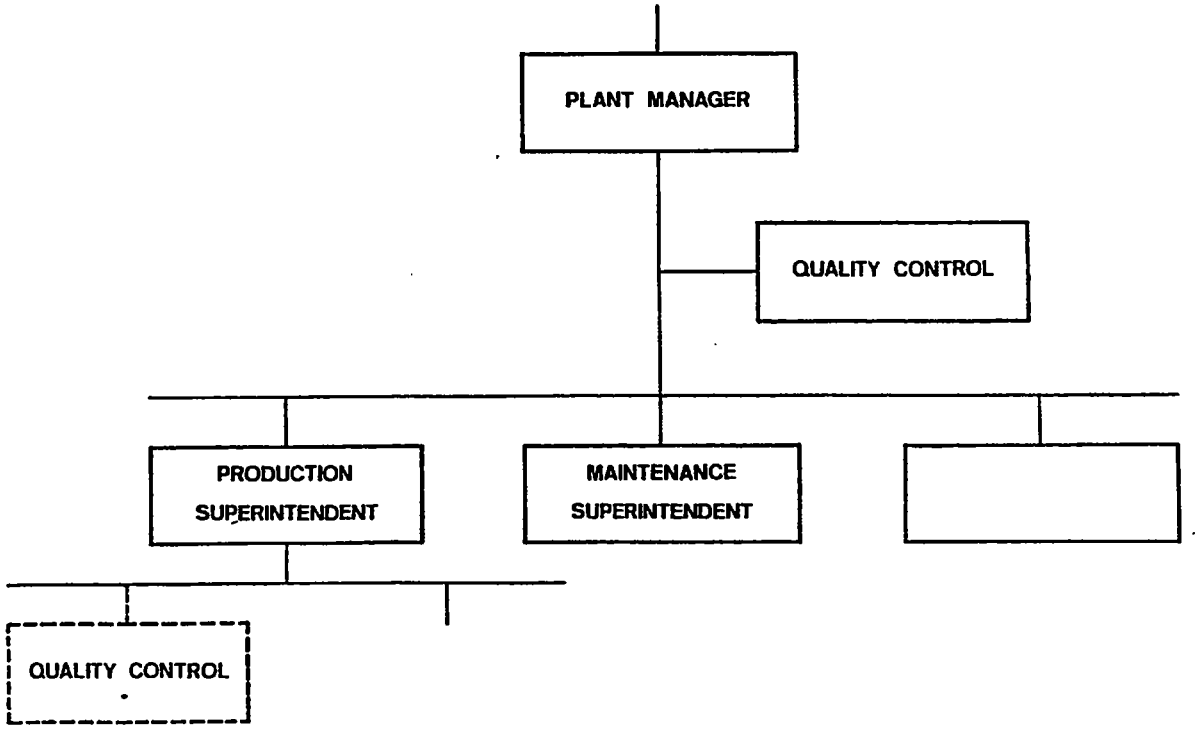
It is the responsibility of the plant managers to supervise, on the basis of operating reports and statistics, the suitability and reserves of the raw materials, the quality of intermediate and final products as well as the conformance of the latter with valid and relevant standards. For these tasks, the plant manager requires an organisation for quality assurance to establish the required information and data, and thus to prepare proposals in the context of quality assurance on which the plant manager can base his decisions.

There are several ways of organising quality assurance: again, the right choice is strongly dependent on the significance of quality assurance for the company.

[1] The term quality assurance system is not defined in ISO 8402. The term quality system is defined in ISO 8402 as the organisational structure, responsibilities, procedure processes and resources for implementing quality management.

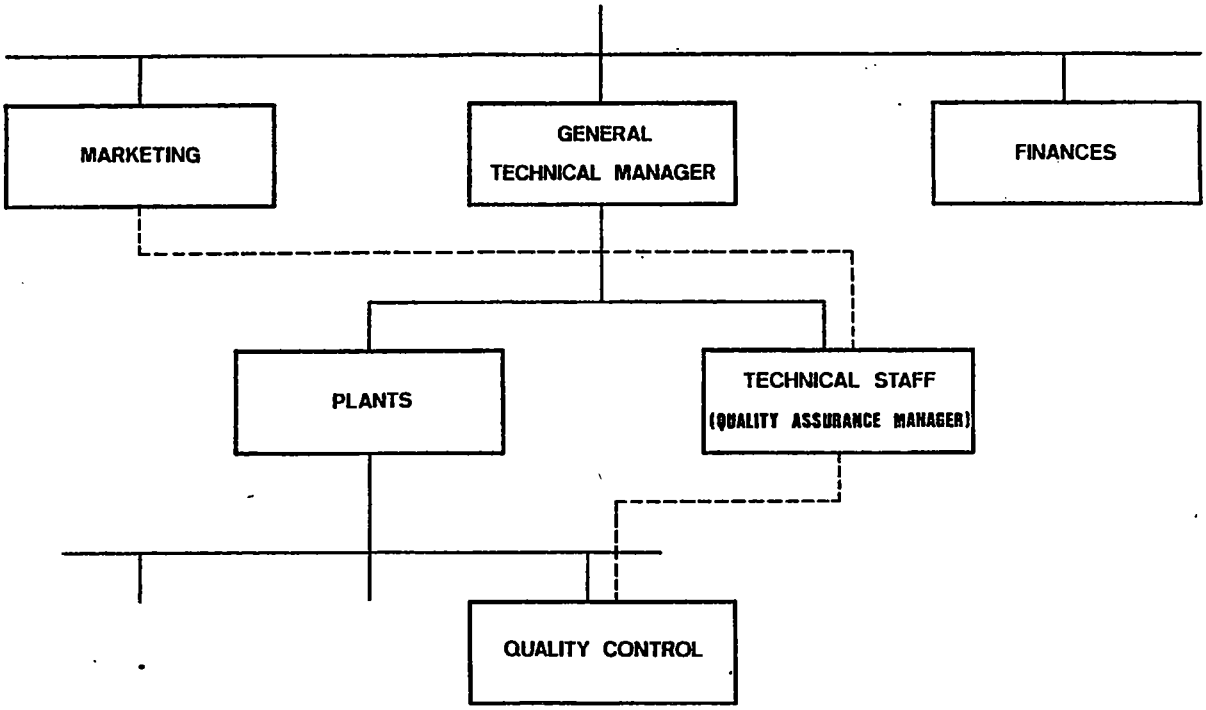
The personnel from the chemical and physical laboratory may be placed in an advisory position (staff function) to the plant manager and is merely responsible for the technical execution of quality control (Fig. 5). Where the aspect of quality control is mainly connected with the process of cement manufacture, a form of organisation is often established in which the production superintendent is directly responsible for the laboratory. These kinds of organisation have, however, the consequence that practically no direct decisions can be taken by the organisation which carried out the actual quality control. All decisions and instructions have to come from the plant manager and this bears the danger of an overburdened and inflated plant management. Moreover, it hinders communication and direct co-operation of the quality control department with other departments which have a strong relation with quality assurance. Consequently, this kind of organisation may serve the needs in a situation where material problems in production are not too complicated and when only a limited product range is supplied to a relatively uncritical market.

Fig 5 "Low Profile" Quality Assurance



Otherwise, the situation implies usually that the scope of the company's quality assurance is split so that various parts of the organisation are actively involved (Fig. 6). The plant laboratory is only concerned with the aspects of quality control in production; in addition to this, a separate group is established to cope with the quality problems directly associated in the application of cement. Such a group for technical customer services is often helpful when a company runs several plants - it is usually part of a company's technical planning and marketing divisions respectively. This form of organisation certainly offers the advantage that in the individual fields of clinker/cement production and of technical consultation of customers, a high level of expertise may be achieved with a limited number of specialists. On the other hand, the following problematic aspects have to be considered:

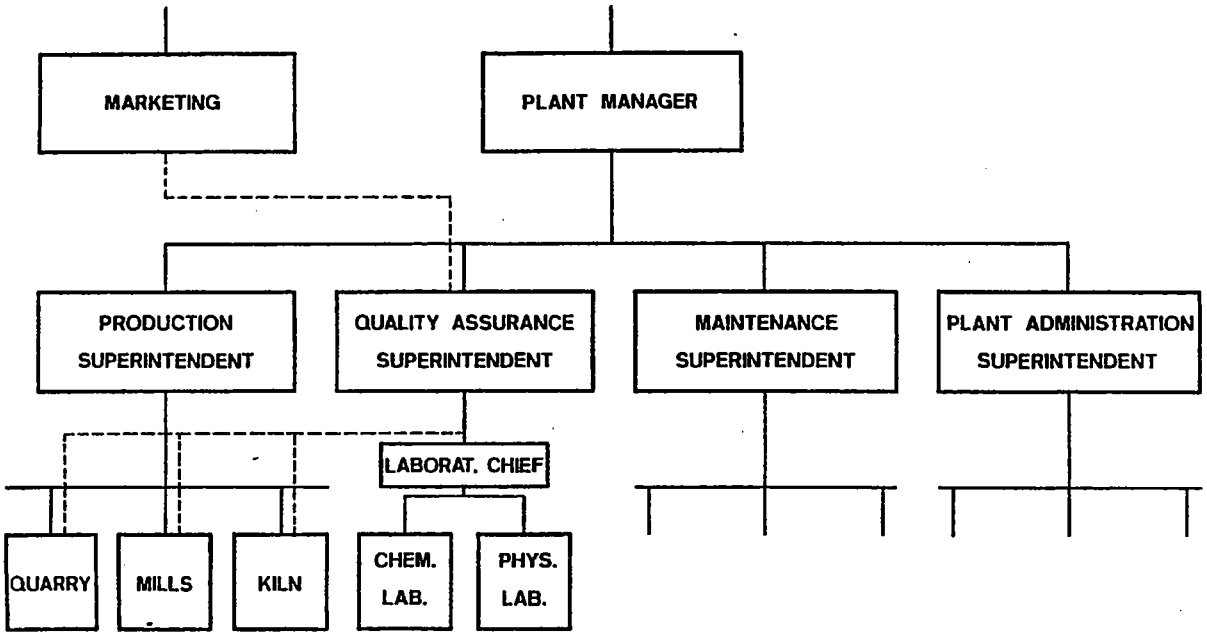
Fig 6 Quality Assurance Organisation in Multi-Plant Company



- An optimum reflection of the entire system of quality assurance from raw materials through the process to cement application is lost. As a consequence of such a partial consideration and the exclusive activity as a service organisation, the interest and comprehension and thus motivation and initiative of the people responsible for actual quality control may be strongly reduced; it thus remains questionable if a continuous optimisation of production and product will still take place.
- Without an organisation which is in a position to consider all relevant aspects of cement manufacture and cement application, there is an inherent danger that the producer's interests are not sufficiently protected against the users' requests on product specifications (e.g. when testing and product specifications are established).

The aim of delegating responsibilities and competence to those who are fully dedicated to quality assurance leads to the assignment of a superintendent of quality assurance within the line organisation of the plant (Fig. 7). Today, this type of organisation is widely applied, most functions of quality assurance are assigned to the quality superintendent who is also responsible for the laboratories.

Fig 7 Typical Quality Assurance Organisation



He reports directly to the plant manager and assists the latter in all matters concerning quality and quantity of raw materials. His further tasks can comprise:

- to advise the production superintendent
- to examine the final products
- to handle technical problems
- to advise plant management and production superintendent on environmental aspects
- to participate in standardisation committees

Before deciding on the one or the other form of organisation for quality assurance, the situation should always be thoroughly analysed. A selection of the organisational form purely on the basis of tradition ("because it always had been this way") is definitely not adequate. Also preferences and dislikes of available personnel should not become decisive factors when organising a company's quality assurance. To achieve an organisation with an optimum efficiency not only in the short but also in the long run, it is essential

- to define clearly the company's tasks of quality assurance, considering prevailing and possible future conditions of raw materials, process and market,
- to formulate duties and responsibilities as well as authority for the personnel in charge of quality assurance (job description, performance standards).

From this, clearly defined requirements as to the qualification of the personnel for quality assurance and hence to the training scheme according to their tasks, can be derived.

Depending on the level of responsibility for quality assurance, this training scheme should not only be limited to techniques of quality control (sampling, testing, data processing), but should also include sound experience in the entire field of cement manufacture and application. Moreover, in addition to the professional skill, basic knowledge and understanding of economic principles and relations is required for the superintendent of quality assurance to achieve the primary goal, namely to make a profit on quality. Being a leader of an organisational entity, he also requires training in the field of leading personnel.

5.3 Quality Assurance Handbook

It is strongly recommended that for every company the quality assurance system and generally all features related to quality assurance are compiled and documented in a "Quality Assurance Handbook". This handbook should be of a binding nature and serves to ensure transparency and efficiency in quality assurance. Although primarily intended for plant internal purposes, the awareness of its existence by customers or official bodies can only be beneficial to the company's quality image.

In order to meet the requirements of national or international standards on quality assurance systems, a comprehensive quality documentation needs to be established. It usually comprises two or three document levels, i.e. a top level quality manual, mid-level quality procedures and lower level work instructions (see Report MA 91/3866/E).

6. QUALITY COSTS

6.1 Introduction

"Quality assurance: from outlay to profit"

It is increasingly recognised that quality assurance is no longer primarily - though inevitably - a cost generating nuisance but represents a valuable instrument to increase profit.

Quality assurance no doubt creates costs - as does any other activity within an enterprise - but, on the other hand, it also allows to reduce unnecessary costs which may arise in case of inadequate quality of services or goods produced.

To ensure the economic benefits of quality assurance, the costs referred to above should be assessed and presented in a transparent way. This is ultimately the most effective way to convince the top management of the benefits of quality assurance, and to obtain their support in establishing and maintaining an integral company policy for quality assurance.

The purpose of assessing the quality costs of a company can be summarised as follows:

a) the quality cost assessment allows to recognise and to rank weak points. It makes evident what kind of deficiencies generate the highest (additional) costs at what stage of production. Measures to improve quality and quality control can be implemented accordingly. Also, sectors apparently causing very high control costs can be re-assessed as to whether the risks justify the costs.

b) quality costs serve as basis for a cost/benefit calculation in connection with planned investments for production installations and for the instruments of quality control. Also the consequences of changes in personnel structure can be estimated on this basis.

c) quality costs can represent a motivation at all levels to increase the efficiency of quality assurance

d) quality costs may permit a comparison with similar enterprises. This, however, requires due precaution because either the assessment of quality costs or the means of production or both may be different.

6.2 Elements of Quality Costs

Quality costs are in general terms defined as the difference between the real expenditures and revenues and those which would arise, if no quality related failures during product development, manufacture and marketing would and could occur.

It is generally accepted that quality costs should be subdivided into three elements:

QUALITY COSTS
Prevention Costs + Appraisal Costs + Failure Costs

Applied to the cement industry, these cost categories can be characterised in the following way:

6.2.1 Prevention Costs

These basically comprise the costs arising in connection with quality planning as outlined in chapter 4.1.

Cost compilation may be unproblematic as far as it concerns the QA-internal personnel costs. For the investigations involving other departments - which is often the case - the fraction of "quality costs" is difficult to determine and would have to be estimated.

6.2.2 Appraisal Costs

These comprise all expenditures of quality control:

- personnel costs
- costs of accommodation and infrastructure
- purchase and amortisation of equipment
- consumables

These costs can easily be ascertained.

6.2.3 Failure Costs

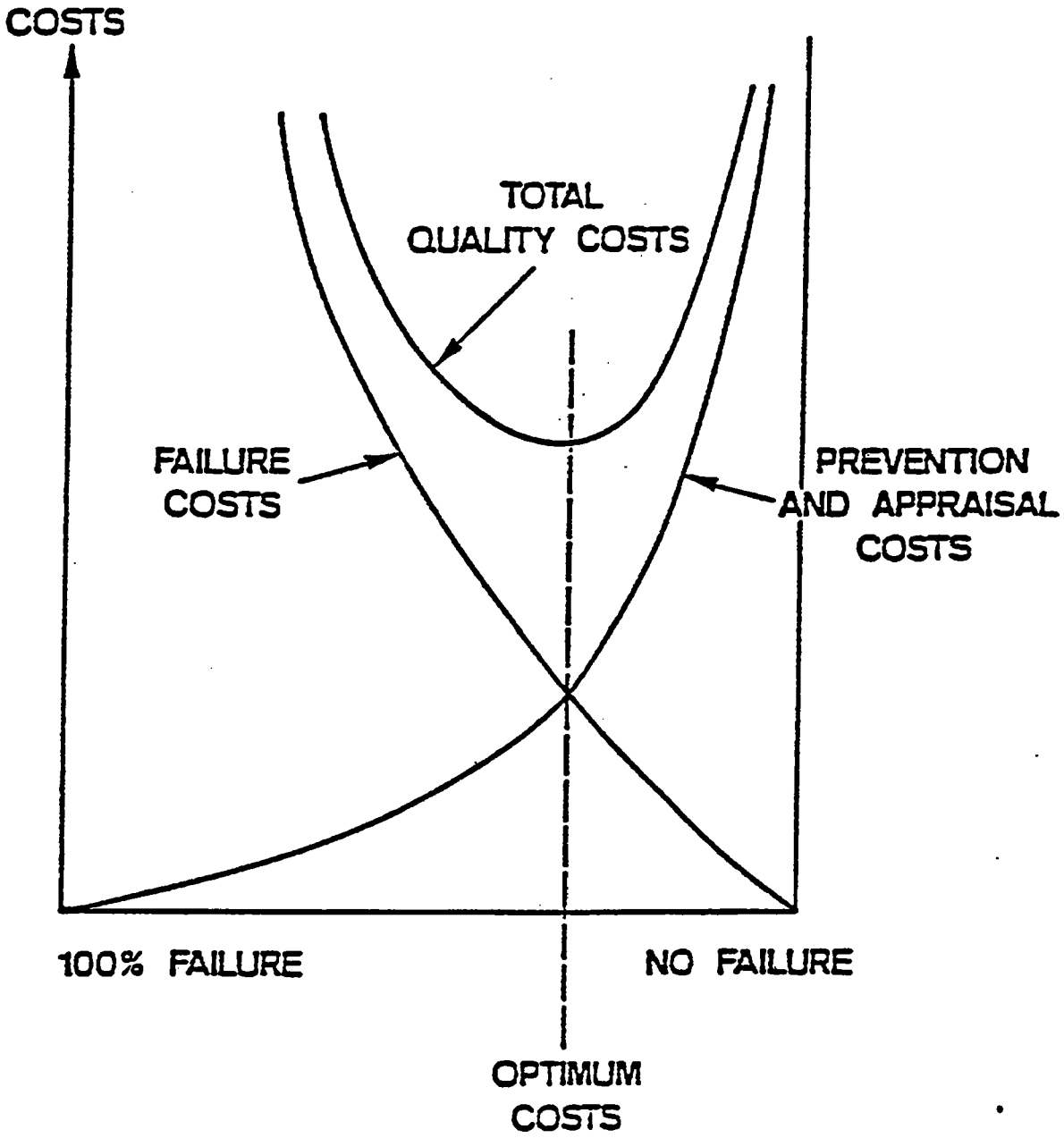
Failure costs are additional costs or non-realised revenues arising as a result of inadequate quality ("non-quality") of intermediate or final products. They can have most different origins as documented by the following list which is by no means exhaustive:

- undue consumption of expensive corrective material on account of non-optimal mix design
- elevated heat consumption, reduced production rate, or excessive refractory wear due to inappropriate raw mix quality
- increased cement grinding energy (higher fineness) due to inadequate clinker quality
- separate storage and blending of under-burnt clinker - . addition of costly "quality improvers" upon cement grinding when using inferior (e.g. outdoor stored) clinker
- use of off-specification special clinker as ordinary clinker
- treatment of customer complaints; payments for damage in cases of failure in cement application
- sales losses owing to manufacture of not market-conform products or due to loss of confidence after a case of damage.

It is evident that a comprehensive quantitative assessment of these failure costs is very difficult.

The relation between these three cost elements is shown in figure 8.

Fig 8 Relationship between Quality Cost Elements



6.3 Relationship of Quality Costs to Sales

Reliable figures for quality costs in the cement industry are not available, mainly due to the lack of a quantitative assessment of failure costs. Reasonable estimates of the expenditure for personnel, equipment and infrastructure associated with quality assurance, which may be taken as a rough approximation of the prevention and appraisal costs, reveal figures in the order of 1 to 2% of the cement net sales price. Sound estimates of the failure costs ("non-quality" costs) are not available; ad-hoc estimates range between 5 and 20 % of net sales price

For comparison, some figures related to other industries for quality costs and improvements achieved after optimisation are given in figure 9.

Fig. 9 Quality costs in different industries before and after optimization, expressed as a percentage of turnover.

Industry	before	after
motor cars	6- 9	4-6
chemicals - raw materials	5- 8	3-5
food	7-12	3-6
chemicals - complex products	7-12	4-7
ceramics	15	10
overall average	11	6

The different types of quality costs before, during an after successful optimisation, expressed as a percentage of turnover.

	Before	during	after
prevention	0.5	1.5	1.0
appraisal	3.5	3.0	2.5
consequential	7.0	4.0	2.5
total	11.0	8.5	6.0